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FISHES OF BLY TUNNEL, LASSEN COUNTY, CALIFORNIA

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ABSTRACT.—Leon Bly Tunnel, which connects Eagle Lake to Willow Creek, was investigated to see if the water issuing from the tunnel was lake water or spring water and to check reports of its being inhabited by fish. We found that the water was similar to that of highly alkaline Eagle Lake, despite a block placed in the tunnel in 1986. Five species of fish were found in the tunnel, the same species inhabiting both Willow Creek and Eagle Lake, although the creek was much warmer and less alkaline than the lake. The fish originated from the creek. Fish in the tunnel were either not feeding or were consuming snails (*Vorticifex* sp.), the principal invertebrate present. The largest fish (35 cm SL) captured were rainbow trout (*Oncorhynchus mykiss*).

Key words: Eagle Lake, rainbow trout, Lahontan redside, fish.

Leon Bly Tunnel was constructed in 1923 to deliver water from Eagle Lake, a large natural lake on the western edge of the Great Basin, Lassen County, California (lat. 40° 37′, long. 120° 45′), to the Honey Lake Valley for irrigation. The tunnel is about 2 km long and was cut through old lava flows. The water flows from the tunnel into a ditch that joins Willow Creek, a spring-fed stream. The tunnel was abandoned as a source of irrigation water shortly after it was built (1936) because falling lake levels reduced its ability to deliver water and a landslide partially blocked the tunnel entrance (Amesbury 1971, Purdy 1988). However, water continued to flow from the tunnel, and in November 1986 the Bureau of Land Management installed a concrete plug in the tunnel in an attempt to raise the lake level (Purdy 1988). In June and July 1990 we investigated the tunnel to see (1) if the water issuing from it was lake or spring water and (2) if there were fish in it. The latter aspect was investigated because of local tales that the tunnel was full of "blind cave fish."

STUDY AREA

Eagle Lake is a large (ca 12,500 ha) terminal lake that is alkaline (pH 8.5–9.1) and very productive (Huntsinger and Maslin 1976). It contains the only population of rainbow trout (*Oncorhynchus mykiss aquilarum*) native to the Great Basin (Busak et al. 1980), as well as tui chub (*Gila bicolor*), speckled dace (*Rhinichthys osculus*), Lahontan redside (*Richardsonius egregius*), and Tahoe sucker (*Catostomus tahoensis*). Bly Tunnel begins at the lake on the eastern shore of the southernmost of the lake's three basins but can only be entered at its mouth. A steep shaft about halfway along its length was used during the 1923 excavation and is currently barred by a locked gate. The tunnel itself is 2.1 m high and 2 m wide at the base, with walls that are about half bare rock, half concrete. The water in the tunnel is 40–50 cm deep and forms riffles and pools in places where rock has fallen into the tunnel or sand and debris have accumulated on the bottom. After leaving the tunnel, the water flows 600 m through a long, shallow ditch (average depth about 30 cm) that has little cover for fish. The ditch empties into Willow Creek, which has its origins about 1 km upstream in a series of seeps and springs that coalesce in a large, wet meadow. Willow Creek, tributary to the Susan River, contains the same fish species as Eagle Lake, with the addition of Paiute sculpin (*Cottus beldingi*), although rainbow trout are very scarce and found primarily in the 1 km of stream below the mouth of the ditch. These trout probably originated from fish planted in the stream at some earlier time.

METHODS

Total alkalinity and hardness (both as mg $CaCO_3$ per L) were measured using Bausch

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TABLE 1. Some characteristics of the water of Eagle Lake, Bly Tunnel, and Willow Creek, June 1990.

	Conductivity	Alkalinity[a]	Hardness[a]	Temperature (C)	Flow (m^3/min.)	Time	Date
Eagle Lake	910	440	280	18[b]	—	1015	6/29
Bly Tunnel	860	410	260	11	4.4	1530	6/19
Headwater springs	180	60	80	21	2.0	1430	6/19
Willow Creek[c]	380	380	200	21[d]	7.7[e]	1430	6/23

[a]Mg $CaCO_3$/L.
[b]Surface temperature; coldest temperature (at 14 m) was 14 C
[c]Just below convergence with ditch from tunnel
[d]The spring flows warmed to 25 C and the tunnel water to 18 C by the time they converged.
[e]Other springs contribute to flow as well as headwater springs.

and Lomb Spectrokits (titration). Conductivity was measured using a Hach portable conductivity meter. Water velocities were determined using a Marsh-McBirney Model 201 electronic flow meter. Flows (m^3/min) were approximated at each locality by measuring depths and mean water column velocities at 10 evenly spaced places on a transect across the stream and then multiplying width by mean water column velocity (m/sec) by mean depth by 60. Fishes in Willow Creek were collected with a Smith-Root Type XI electrofisher at numerous localities during 17 June–15 July 1990 as part of a detailed study of the creek's fish fauna. The tunnel fauna was sampled on 4 July 1990 between 1300 and 1500 hr. Only the first 600 m of tunnel was investigated, and at the farthest point the light from the end of the tunnel was still faintly visible. The conductivity of the tunnel water was too high for electrofishing, so fish were collected with dipnets. This proved easy to do, as they were confused by the light from our flashlights. Samples of fish from the creek and the tunnel were killed and then preserved in a 4% formaldehyde solution for dietary analysis. Diets were determined by identifying the stomach contents and estimating relative volumes of each item using the points method of Hynes (1950). Most fish were discarded after use, but voucher specimens are in the University of California, Davis, fish collection. Tunnel invertebrates were sampled with a kick screen.

RESULTS

The chemistry of the water issuing from the tunnel had a high conductivity, hardness, and total alkalinity (Table 1). All values were only slightly lower than those of Eagle Lake and much higher than those of spring water feeding Willow Creek. Temperature of the tunnel water was 11 C, colder than either the stream or lake (Table 1). At the point it flowed into the creek it had warmed to 18 C (late afternoon). The outflow of the tunnel contributed more than half the flow of Willow Creek, raising its alkalinity, hardness, and conductivity. The tunnel water also caused lower temperatures in the creek in a reach ca 500 m below the ditch entrance. However, because the stream is wide, shallow, and without riparian vegetation (due to heavy grazing), the water temperatures below this reach were typically 23–24 C by late afternoon in late June and early July.

Fish were common in the tunnel and were first noticed approximately 20 m up from the entrance. In order of abundance, the fishes collected were Lahontan redside (25), Tahoe sucker (6), speckled dace (5), rainbow trout (2), and tui chub (1), although speckled dace and Tahoe sucker may have been undersampled because of their tendency to hide in bottom debris or in crannies along the side of the tunnel. In Willow Creek the fishes present, in order of numerical abundance, were speckled dace, Lahontan redside, Tahoe sucker, tui chub, Paiute sculpin, and rainbow trout. The size classes of fish encountered in the tunnel were similar to those found in the stream, except that young-of-year fish (<30 mm SL) seemed to be absent and the two rainbow trout captured were larger than any taken from the stream. The largest trout, which was captured and released, was a hook-jawed male in spawning colors 350 mm SL. The other trout was a 184-mm-SL male. The largest fish other than trout were two 140–150-mm-SL suckers that were also captured and released. All fishes captured were similar in coloration to fish in the stream, and the

TABLE 2. Percentages of items in diets of fishes from Willow Creek and Bly Tunnel, Lassen County, California, in July 1990. A more detailed taxonomic breakdown of the gut contents is available from the senior author.

	N	SL (mm)	No. empty stomachs	Odonata	Ephemeroptera	Trichoptera	Coleoptera	Hemiptera	Diptera	Gastropoda	Misc. invertebrates	Algae/detritus
Lahontan redside												
Tunnel	16	75	10	—	—	—	—	6	7	86	1	—
Creek	50	59	15	—	12	18	4	5	4	9	16	32
Speckled dace												
Tunnel	5	41	5	—	—	—	—	—	—	—	—	—
Creek	55	38	39	8	71	7	—	6	2	3	—	3
Tui chub												
Tunnel	1	60	1	—	—	—	—	—	—	—	—	—
Creek[a]	18	57	1	10	56	—	2	2	—	10	15	5
Tahoe sucker												
Tunnel	4	99	3	—	—	—	—	—	—	5	—	95
Creek[a]	24	70	2	12	26	12	2	—	30	2	12	2
Rainbow trout												
Tunnel	1	184	0	—	—	—	—	—	—	100	—	—
Paiute sculpin												
Creek	21	51	8	59	6	9	—	—	6	2	17	—

[a]Excludes unidentifiable material which made up >70% of gut contents.

larger redsides had traces of red on their sides (as did the creek fishes), remnants of spawning colors (Moyle 1976). All fish appeared healthy and showed no signs of starvation. The only fish observed in the ditch between the creek and the tunnel were a few small speckled dace, which we were unable to capture. Two standard minnow traps set overnight at the mouth of the tunnel failed to catch any fish, although such sets are generally successful in Willow Creek.

The guts of fishes collected from the tunnel were either empty or full of *Vorticifex (Paraphlox)* sp., a snail that was the principal aquatic invertebrate collected in the tunnel and which literally coated the bottom in places. Two redsides, however, also contained some adult insects (Table 2). Snails were relatively uncommon in the diets of Willow Creek fish, which fed primarily on aquatic insects. The only aquatic invertebrates besides snails collected in the tunnel were large annelid worms.

DISCUSSION

The highly alkaline water flowing through Bly Tunnel clearly has its source in Eagle Lake. Presumably, underground passage cools the water to 11 C. The fish, however, most likely moved up from Willow Creek, as they are roughly in the same relative abundances in the tunnel as in the creek, except for the absence of sculpins. Further evidence of this is that the rainbow trout captured were clearly wild fish (although not native to the drainage), with the fin conformations associated with wild fish. Trout in the lake are all the result of planting, and most have deformed fins from their hatchery rearing; in addition, they are planted at sizes larger (25–30 cm) than most trout in the tunnel and creek. Scales from the 184-mm trout indicated that it was 2+ years old, a fairly typical size for a stream rainbow trout (Moyle 1976). The ages and growth patterns of Lahontan redsides from the tunnel, as revealed by examination of scales, did not seem to differ from those of stream fish.

It seems likely that the fish are recent invaders of the tunnel. Presumably, they moved up earlier in the year when the water in Willow Creek was cooler and there was less of a temperature gradient. The clear water of the outflow ditch provides little shelter from bird predation, so fish are likely to persist in this area only if they move into the tunnel. We have observed Common Mergansers in the ditch, and our studies of Willow Creek indicate that predation by several species of birds is a major factor limiting fish populations (unpublished data). Although we failed to catch any fish in minnow traps set near the tunnel mouth, the presence of adult insects in two redside stomachs indicates either that individuals occasionally may venture out to feed or that individuals are continually arriving despite the temperature gradient and their vulnerability to predators in the ditch. Speckled dace may venture out to feed at night, the time they are most active in the creek, but the other fishes are more active during the day (unpublished data). The healthy appearance of all fish indicates they are not starving under tunnel conditions.

This study also shows that the attempts to block Bly Tunnel to keep it from draining Eagle Lake have been at best only partially successful. The comparatively low flows now coming out of the tunnel may simply be the result of low lake levels following a long series of dry years. If the lake level rises again, outflow of the tunnel should be monitored and further attempts made to block the outflow if it is found to be keeping the lake at an artificially low level.

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LITERATURE CITED

AMESBURY, R. 1971. Eagle Lake. Privately published, Susanville, California.

BUSAK, C. A., G. A. THORGAARD, M. P. BANNON, AND G. A. E. GALL. 1980. An electrophoretic, karyotypic, and meristic characterization of the Eagle Lake trout. Copeia 1980: 418–424.

HUNTSINGER, K. R., AND P. E. MASLIN. 1976. A limnological comparison of the three basins of Eagle Lake, California. California Fish and Game 62: 232–245.

HYNES, H. B. N. 1950. The food of fresh-water sticklebacks (*Gasterosteus aculeatus* and *Pygosteus pungitius*) with a review of methods used in studies of the food of fishes. Journal of Animal Ecology 19: 36–58.

MOYLE, P. B. 1976. Inland fishes of California. University of California Press, Berkeley. 402 pp.

PURDY, T. I. 1988. Purdy's Eagle Lake. Lahonton Images, Susanville, California.

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